Ranking of Job Applicants, On-the-job Search, and Persistent Unemployment*

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We formulate an efficiency wage model with on-the-job search where wages depend on turnover and employers may use information on whether the searching worker is employed or unemployed as a hiring criterion. We show theoretically that ranking of job applicants by employment status affects both the level and the persistence of unemployment and numerically that these effects may be substantial. More prevalent ranking in Europe compared to the US (because of more rigid wage structures etc.) could potentially help to explain the high and persistent unemployment in Europe.

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When one compares European and US labor markets, several differences are apparent. Unemployment rates are much higher, turnover is much lower, and the adjustment back to equilibrium after a shock is much slower in Europe. While high unemployment may plausibly be blamed on unions and labor market rigidities and low turnover may be due to cultural differences, the last observation is especially intriguing. In several European countries, unemployment has remained high for a long time after it was raised by temporary cyclical shocks. In univariate models of unemployment, the coefficient on lagged unemployment is close to unity for many European countries (see references below). Adjustment costs and insider-outsider models can explain some persistence, but they can hardly generate the extreme persistence found in the data. Why is unemployment so persistent in Europe? In this paper we take a new look at this question, emphasizing two aspects of the labor market: that turnover considerations affect wage setting and that firms sometimes prefer to hire employed rather than unemployed job applicants.

The importance of voluntary turnover is well documented. Holmlund (1984) and Akerlof, Rose and Yellen (1988) report quit rates of around two percent per month for the US, Sweden and Japan, and Boeri (1999) finds that worker flows from one job to another constitute around 50 per cent of all hiring in several European economies. Pissarides and Wadsworth (1994) report that around 5 per cent of all employed workers in Britain search for a new job and according to Holmlund (1984) about 8 percent of employed workers in Sweden engage in job search during a year. Lane, Stevens and Burgess (1996) show that worker reallocation is two to three times as great as job reallocation and labor turnover is procyclical because procyclical quits dominate counter-cyclical layoffs (Anderson and Meyer (1994)). McCormick (1988) shows that total separations, many of which are job-to-job flows, depend strongly on the number of available vacancies. Furthermore, survey evidence shows that firms do consider the implications for turnover when they set wages. Concerns about hiring and training costs and loss of competence due to turnover deter firms from wage cuts (Blinder and Choi (1990), Campbell and Kamlani (1997)).

The second starting point is that unemployed workers are sometimes at a disadvantage compared to employed workers in the competition for jobs because some employers prefer to hire already employed workers. Blau and Robins (1990) show that in the US employed job searchers receive almost twice as many job offers as unemployed searchers with the same search effort. Winter-Ebmer (1991) finds that employment status is used as a screening device for productivity in Austria. In surveys of US and Swedish firms, Bewley

(1999) and Agell and Lundborg (1999) find that a substantial fraction of employers view unemployment as a signal of lower productivity.

If there is search on the job, and turnover is costly, then the firm's optimal wage will depend on the probability that its employees find other jobs. If this probability increases, firms will raise wages to prevent costly turnover. If, in addition, unemployed workers do not compete for jobs on an equal basis with employed applicants, this must raise the probability for employed workers to get the jobs they apply for, and raise the wage. In other words, we should expect an *interaction* between the turnover considerations that affect wage setting and the fact that unemployed workers have a disadvantage compared to employed workers when applying for the same jobs. The bigger this disadvantage, the higher is the chance for employed workers to get a new job, and the higher is, ceteris paribus, the "efficiency wage" that is optimal from the firm's point of view.

To formalize this intuition, we formulate a model where a fraction of all employed workers apply for new jobs while maintaining their current jobs. Whether a person applies for a new job or not depends on the wage offered by the current employer, wages elsewhere, and a stochastic job satisfaction factor associated with the current job. The firm takes the effect on turnover into account when it sets the wage. We first consider the case without ranking, i. e. when employers choose whom to hire randomly. We find that, without ranking, unemployment is somewhat persistent. Because firms fear costly turnover as the economy recovers from a recession, a permanent negative shock is not fully accommodated in the next wage contract, and hence employment remains low for some time after a negative shock.

We then introduce *ranking* by assuming that some employers prefer to hire *employed* applicants. Ranking increases the probability that an employed worker gets the job he applies for and this makes it optimal for firms to set higher wages. The result is both higher equilibrium unemployment *and* slower wage adjustment following a shock. When the economy is recovering from a recession, there are relatively many job openings, which tend to raise wages, and high unemployment has only a weak effect on wages because unemployed workers do not compete well with those searching on the job. Simulations show that the quantitative effects of ranking may be substantial.

We also use the model to interpret the different labor market outcomes in the US and Europe. Both the *level* and the *persistence* of unemployment are much higher in Europe. Our simulations show that, within this model, wage pressure due to strong unions can explain high unemployment in Europe, but not the extreme persistence observed empirically. Instead, our analysis points to ranking of job applicants as a potentially important explanation of the high persistence of unemployment observed in many European labor markets. Unfortunately, we do not have direct measures that allow us to compare the extent of ranking across countries, but we find it plausible that ranking is more prevalent in Europe because of more rigid wage structures etc.

The idea that unemployment persists because unemployed workers have difficulty competing for jobs is not new. Phelps (1972), Layard and Nickell (1986) and others[1] have made arguments along those lines, but there are few microeconomic models formalizing the idea. The insider bargaining model developed by Blanchard and Summers (1986) and Gottfries and Horn (1987) emphasizes the distinction between employed and unemployed workers, but can hardly generate the extreme amount of persistence found in the data.[2] Other related papers are Huizinga and Schiantarelli (1992) and Gottfries and Westermark (1998), who show that persistence may arise due to the forward looking nature of wage decisions, and Pissarides (1992), who shows that interaction between skill loss in unemployment and job creation by firms can make unemployment more persistent. Neither of these papers considers the interaction between on-the-job search, ranking, and wage-setting that we emphasize here.[3]

The paper that is most closely related to ours, is Blanchard and Diamond (1994). They examine how *wages* are affected if firms rank job applicants according to the length of unemployment. Workers and firms match in a random way and wages are determined by Nash bargaining, with the expected utility of a recently laid off worker as threat point. Their result is that ranking affects wage dynamics but has small effects on the long run wage level. Our analysis differs in several ways. First, we replace the "quasi labor supply curve" implied by Nash bargaining by an efficiency wage model with turnover between jobs; as a consequence, the utility that workers get if they are unemployed plays no role in our model. Second, we focus on the advantage of employed job searchers relative to the unemployed

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1 See also references in Machin and Manning (1999).

2 In univariate models of unemployment, the coefficient on lagged unemployment is close to unity for many European countries (see references below). The Blanchard and Summers (1986) version of the insider bargaining model generates hysteresis, which is an extreme form of persistence, but only because they make very special assumptions concerning union preferences etc. - see the discussion in Blanchard (1991) or Bean (1994).

3 Pissarides (1992) assumes that long-term unemployment leads to loss of skill. Firms cannot distinguish long-term and short-term unemployed, so all job seekers have the same chance to get a job. Unemployment is persistent because long term unemployment implies a deterioration of the average quality of unemployed workers, which makes it less profitable for firms to create vacancies. Thus the mechanisms are quite different from those considered here. Pissarides (1994) introduces on-the-job search into an equilibrium search-matching model, but the interaction with ranking is not explored.

workers rather than on the distinction between short-term and long-term unemployed. Third, while Blanchard and Diamond examine the effects on wages of exogenous movements in employment, employment is endogenous in our model, so we can solve for employment, calculate persistence, and evaluate the effects quantitatively. Also, our results differ from those of Blanchard and Diamond. In our model, ranking has substantial effects not only on the dynamics, but also on the long run equilibrium levels of wages and employment.[4]

In Section I we formulate the basic turnover model without ranking and calculate steady state employment and persistence. In Section II we introduce ranking and show that this increases the level and the persistence of unemployment. In Section III we extend the model to allow for wage contracts spanning several periods and in Section IV we discuss potential explanations of the observed differences between European and the US labor markets. In Section V we discuss some of the simplifying assumptions in our model and relate our results to the relevant literature.

I. The Model without Ranking

The model is very stylized and formalizes the idea that job-to-job flows are substantial and firms care about turnover when they set wages. There are many monopolistic firms and many workers per firm. The labor force is constant and normalized to one. The sequence of events in each period is the following:

i) At the beginning of the period, some of the workers leave employment and enter the pool of unemployment. The fraction leaving to unemployment, s, is exogenously given and represents workers quitting or being laid off for exogenous reasons.

ii) Firms set wages and prices.

iii) The remaining employed workers decide whether to apply for a new job or not, considering the wage offered by the current employer, wages elsewhere, and a non-pecuniary "job satisfaction" factor. All unemployed workers also search and every searcher submits one application to a randomly chosen firm.[5]

[4] In a recent paper by Tranaes (2001), firms can choose between searching among the unemployed and making job offers to workers employed by other firms. Unemployed workers have a disadvantage because there are some unemployable workers among them. He does not address the persistence problem, however.

[5] Whether workers send in one or more applications is less important. The important assumption is that the search intensity is the same for all searchers.

iv) Firms receive the applications and observe the aggregate demand shock, m_t. Since price exceeds marginal cost, it is optimal to hire the number of workers required to satisfy demand. We assume that the shocks are never so large that they cannot find workers to hire. In the no-ranking case they choose randomly among the job applicants. In the case of ranking, firms prefer to hire employed applicants for some, randomly chosen jobs.

Since the decision in stage iv is trivial, we proceed by first analyzing the search decision of the worker in stage iii, and then analyzing the firm's optimal wage and price decision in stage ii. Finally we examine employment dynamics in a symmetric general equilibrium and calculate the natural rate of unemployment and its persistence.

On-the job Search

Every worker who remains employed when a period begins has to decide whether to look for a new job or not. We assume that each worker employed at the beginning of a period draws a number n that determines his job satisfaction from working at his present job in the current period.[6] This number is drawn from a random distribution with cumulative distribution function G(ν) which is unimodal with mean equal to unity and an upper support $\bar{n}$. To keep the model simple, we assume that every worker makes a new independent draw from $G(n)$ every period.[7] If an individual worker in firm i draws the number $\hat{n}$ his utility from staying this period is $w_t^i/\hat{n}$, where w_t^i is the wage set by firm i in period t. Assuming that all other firms set wage w_t the expected utility from a randomly chosen new job is $lE(w_t/n)$ where λ is smaller than unity, reflecting costs of switching jobs. Workers find out the level of job satisfaction in a new job only after they have taken it.

There are no costs associated with on-the-job search, so a worker who has drawn $\hat{n}$ will search for a new job if $lE(w_t/n) > w_t^i/\hat{n}$. We assume that $lE(1/n) < 1$, so if wages are the same, most workers prefer to stay at the job they have. We also assume that the upper support is not so high that workers may prefer to quit into unemployment. These assumptions imply that the fraction of on-the-job searchers in firm i in period t is

$$S(w_t^i / w_t) = 1 - G(w_t^i / w_t \, lE(1/n)) , \qquad (1)$$

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[6] Akerlof, Rose and Yellen (1988) emphasize that both wages and non-pecuniary factors influence quit decisions.

[7] This assumption is discussed below.

where S is decreasing and convex when the relative wage is near unity.[8] Note that because there is no cost of search, the decision to search does not depend on the chance to get a job – only on whether the worker would like to change jobs.

All searching workers apply for one job each period and submit their applications randomly. The fraction of previously employed workers quitting to take another job is then $(1-s)S(w_t^i / w_t)a_t$, where a_t is the probability that an employed searcher finds a job. This probability will be determined below.

Wage- and price-setting

Every worker produces one unit of the good, $q_t^i = n_t^i$, and the demand for the firm's product is a constant-elastic function of the firm's relative price and the real money supply: $q_t^i = (p_t^i / p_t)^{-\eta} m_t / p_t$. The stochastic "money supply" m_t represents various aggregate demand shocks and firms set prices and wages at the beginning of the period, before they observe m_t.

When setting the wage, a firm takes account of the fact that labor turnover is costly.[9] For every worker the firm hires, it incurs a hiring cost equal to c times the average wage, w_t. We assume that voluntary quits are sufficiently large, and negative shocks are not too large, so that all employment adjustments can be made by variations in hiring.[10] Then, the number of workers hired is $n_t^i - (1-s)\left(1 - S\left(w_t^i / w_t\right)a_t\right)n_{t-1}^i$. The firm has discount factor β and it will choose w_t^i and p_t^i to maximize:

$$\mathrm{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left\{ \left(p_\tau^i - w_\tau^i\right) n_\tau^i - c w_\tau \left[n_\tau^i - (1-s)\left(1 - S\left(w_\tau^i / w_\tau\right) a_\tau\right) n_{\tau-1}^i \right] \right\} \qquad (2)$$

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[8] For a very low relative wage, most workers leave the firm and S is concave but this region will not be relevant in equilibrium.

[9] In this section we assume that the wage can be changed at the beginning of every period (month). In Section III we generalize this to the case when the wage is set for N periods

[10] This assumption simplifies the analysis because firms always hire some workers. Without it, the probability to get a job, a_t, would hit the lower bound of zero when there are no job openings. Although expected a_t would always be larger than zero, a sufficiently large negative demand shock may imply that there are no job openings. We would then have two regimes for a_t, but it should not fundamentally alter the conclusions. Note also that s includes layoffs for personal reasons etc.

subject to $n_t^i = \left(\frac{p_t^i}{p_t}\right)^{-h} \frac{m_t}{p_t}$.

Substituting the constraint into the objective function and maximizing with respect to w_t^i and p_t^i, we get the first order conditions for period t:

$$w_t^i: \quad E_t\left\{-n_t^i - c(1-s)S'(w_t^i / w_t)a_t n_{t-1}^i\right\} = 0, \tag{3}$$

$$p_t^i: \quad E_t\left\{(1-h)n_t^i + \left(w_t^i + cw_t - bcw_{t+1}(1-s)(1-S(w_{t+1}^i / w_{t+1})a_{t+1})\right)h\frac{n_t^i}{p_t^i}\right\} = 0. \tag{4}$$

The first condition says that the optimal ”efficiency wage” is such that the direct cost of a marginal wage increase equals the reduction in turnover costs associated with a higher wage. The optimal wage depends on the average wage level, the hiring cost, and the probability that someone searching on the job will get a job.

Since the firm will always satisfy demand ex post, the firm is effectively choosing expected employment when it sets the price. The pricing decision is complicated by the fact that the marginal cost includes not only the hiring cost this period, but also the reduction of hiring costs next period if a worker is hired today rather than the next period. The probability that a worker, who is hired today, remains next period depends on the labor market situation next period. Thus, the firm faces a dynamic optimization problem in its price/employment decision. As we will see, we do not need to solve this dynamic optimization problem to solve the model, however.

The Level and Persistence of Unemployment

Since we are interested in aggregate employment, we consider a *symmetric general equilibrium* where all firms enter with the same employment and set the same wage.[11] Then we have from equation (3):

$$E_t[n_t] = \Omega(1-s)n_{t-1}E_t[a_t], \tag{5}$$

[11] We assume that all firms set the wage at the same time so we do not have overlapping contracts. Obviously, overlapping contracts of the Taylor variety may generate persistence, but we want to examine how much persistence we get in the model without this additional source of persistence.

where Ω = -c S'(1) is a measure of the "wage pressure" arising from the efficiency wage mechanism. Wage pressure is higher the higher the turnover cost and the more sensitive quits are to wage changes. We assume that Ω(1-s)>1 so that $E_t[a_t]<1$ when employment is approximately constant.

The final step is to find an equation for a_t, the probability to get a job. There are many more workers than firms, and we assume the parameters to be such that each firm gets at least as many applicants as it has job openings.[12] In this section we consider the case without ranking where the firm has no preferences between employed and unemployed workers but simply draws the desired number of workers randomly from the pile of applications. Then the probability to get a job is total hiring divided by the total number of workers searching:

$$a_t = \frac{n_t - (1-s)(1-Sa_t)n_{t-1}}{1-(1-s)n_{t-1} + (1-s)Sn_{t-1}}, \tag{6}$$

where we simplify notation by writing S(1)=S. Hiring is the number of workers the firm wishes to employ minus the workers who remain from last period, taking into account exogenous and endogenous separations. Searchers consist of both unemployed workers, $1-(1-s)n_{t-1}$, and employed workers searching on-the-job $(1-s)Sn_{t-1}$. Solving equation (6) for a_t we get:

$$a_t = \frac{n_t - (1-s)n_{t-1}}{1-(1-s)n_{t-1}}, \tag{7}$$

which is simply *net* hiring divided by the number of unemployed job seekers. The chance to get a job does not depend on the number of employed workers looking for jobs. The intuition is that every worker who changes jobs leaves one job and takes one job, so the number of jobs available for the remaining searchers remains the same.

Combining (5) and (7) we can solve for expected employment as a function of employment in the previous period:

$$E_t[n_t] = f(n_{t-1}) = \frac{\Omega(1-s)^2 n_{t-1}^2}{(1-s)(1+\Omega)n_{t-1} - 1} . \tag{8}$$

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12 We check that this is true for the numerical parameter values used in the simulations below.

From this equation we can find the steady state employment rate if there are no shocks:

$$n^{SS} = \frac{1}{(1-s)(1+s\Omega)} \quad . \tag{9}$$

Higher wage pressure Ω results in lower employment. An increased flow from employment to unemployment (s) has an ambiguous effect on the natural rate, but for plausible parameter values, it raises unemployment.

Since $n_t = m_t / p_t$ and $E_t(n_t) = E_t(m_t) / p_t$ we can use (8) to derive an explicit dynamic equation for employment as a function of past employment and the monetary shock:

$$n_t = f(n_{t-1}) \frac{m_t}{E_t(m_t)} . \tag{10}$$

Because of wage and price rigidity, unexpected shocks to money supply affect employment, and once employment has increased or decreased, it will tend to remain high (or low) in subsequent periods. As a measure of persistence from one period (month) to the next we use the derivative of the function f evaluated at the steady state level of employment:

$$r_m \equiv f'(n^{SS}) = \frac{(1-2s)u^{SS} - s^2 n^{SS}}{(1-s)(u^{SS} + sn^{SS})} , \tag{11}$$

where u denotes unemployment. This expression is positive for reasonable values for the parameters.

To understand why employment depends positively on employment in the previous period, imagine that we are initially in steady state. Then the money supply falls unexpectedly and permanently. This happens after wages and prices have been fixed, so firms respond by cutting employment (reducing hiring) and employment stays at this lower level until the end of the period. In the next period firms cut their wages, but not so much that employment immediately returns to its steady state value. If wages would immediately fall by the same per cent as the money supply, there would be a large increase in employment, many vacancies, and high turnover. Foreseeing this, each individual firm would then have an incentive to deviate by not cutting the wage so much, so as to reduce turnover. Therefore, the equilibrium solution must be such that wages fall by less than the initial decrease in the money supply, and employment remains low for some periods after the negative shock.[13] Of course, our model is highly stylized, but we would expect the basic mechanism to operate in more general models.[14]

Nominal prices and wages

We have solved for the expected level of employment without using the first order condition with respect to the price. This was possible because the model is recursive so that we can find expected employment in a period without considering what happens in the product market. This is analogous to static models where the natural rate of unemployment is independent of the position of the aggregate demand curve. Unexpected demand shocks do affect employment, however, because of short-term wage and price stickiness. To see this more clearly, we evaluate (4) in a symmetric general equilibrium:

$$1-h+(1+c)h\frac{w_t}{p_t}-bc(1-s)h\frac{E_t\left(w_{t+1}(1-S(1)a_{t+1})\right)}{p_t}-bc(1-s)hk_t=0\,, \tag{12}$$

where k_t is the conditional covariance between $w_{t+1}(1-S(1)a_{t+1})$ and n_t divided by $p_tE_t(n_t)$.[15] Solving for the real wage we get what may be called a "quasi labor demand curve" or a "price setting curve", i. e. the real wage implied by price setting:

$$\frac{w_t}{p_t}=\frac{h-1+bc(1-s)hk_t}{(1+c)h-bc(1-s)hE_t\left(\frac{w_{t+1}}{w_t}(1-S(1)a_{t+1})\right)}. \tag{13}$$

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13 A similar argument is made by Huizinga and Schiantarelli (1992) and Gottfries and Westermark (1998), but those papers did not consider on-the-job search.

14 The assumption that the gain from switching jobs is purely temporary was made to generate turnover without making the model too complicated. Of course, we would expect "job dissatisfaction" ν to be serially correlated in practice. Allowing for persistence in job satisfaction would make the analysis very complicated, however, because different workers' levels of job satisfaction would affect their propensity to search in future periods. Thus the state of the model would include the changing distribution of workers across different levels of job satisfaction. Intuitively, it seems that this would strengthen the persistence, however: if aggregate employment was low in period t-2, turnover was low in that period, and there are many workers with a relatively low level of job satisfaction. This will induce firms to set a high wage, so employment remains low. In this case, wages and employment depend on the whole employment history.

15 Recall that wages and prices are set simultaneously before the stochastic demand variable m_t is observed. In equilibrium, firms realize that all firms are setting the same wages and prices.

In Figure 1 we have drawn the price-setting (PS) curve corresponding to equation (13). We have drawn it downward-sloping but this is not important for the argument.[16] We have also drawn the wage setting (WS) curve corresponding to equation (8). The important point is that the wage setting curve is vertical so whatever expectations firms have about the future, labor market equilibrium implies that firms set wages so that expected employment equals $f(n_{t-1})$.

We may also illustrate the model in the nominal wage-employment space. Since $n_t = m_t / p_t$, (13) implies:

$$n_t = \frac{h - 1 + bc(1-s)hk_t}{(1+c)h - bc(1-s)hE_t\left(\frac{w_{t+1}}{w_t}(1 - S(1)a_{t+1})\right)} \frac{m_t}{w_t}. \qquad (14)$$

Given expectations about future wage growth etc. aggregate employment is a decreasing function of the nominal wage. This relation is denoted D in Figure 2. Whatever the expectations about m_t, w_{t+1} etc., the nominal wage is set so that expected employment equals $f(n_{t-1})$. Unexpected shocks to nominal demand affect employment after nominal wages and prices have been set. In order to find nominal wages and prices we would need to use the price-setting and aggregate demand relations, but if we are only interested in labor market dynamics, we can solve the model using only the wage-setting equation and the equation for the probability to get a job.

II. Effects of Ranking

Having formulated the basic model we are now ready to analyze the effects of ranking. How will ranking affect the basic decisions made by the agents in our model? How will ranking affect the steady state level of employment and the degree of persistence? How big are the effects quantitatively? These are the questions to which we now turn.

Before we incorporate ranking in the model it is important to be clear about what we mean by ranking. In this model, ranking means that employers sometimes, when choosing between applicants for a particular job, prefer to hire someone who has a job rather than to hire an unemployed worker. Formally, we assume that firms rank applicants in this way for a

[16] We have drawn it downward sloping because the expectation in the denominator depends on current employment. If current employment is high, wages are expected to rise and employment to fall. Thus $E(w_{t+1}/w_t)$ is high and $E(a_{t+1})$ is low.

fraction r of the jobs. We assume that there are always enough employed job applicants to fill the jobs, so only employed applicants are hired to those jobs.[17]

Why Ranking?

This definition of ranking raises an important question. Why do firms sometimes prefer to hire already employed applicants? A natural argument is that the perceived productivity of an unemployed worker may be lower than that of an unemployed worker because workers lose human capital in unemployment. In fact, it is enough that unemployed workers are perceived to be slightly less productive to justify ranking, provided that the wage is the same. Then, as long as there are employed applicants available, unemployed workers will never be hired and the lower productivity is never observed. Equivalently, the training cost may be higher for unemployed workers; again this higher training cost would never be paid in equilibrium.

Yet another possibility is that there may be a small number of workers among the unemployed who are unemployable, but this can only be observed after hiring and training, in which case the worker is fired. Then, if the firm hires an unemployed worker, it runs a (small) risk that it will pay the training cost in vain and this will be equivalent to a higher hiring cost for *all* unemployed workers. Again, firms will rationally discriminate unemployed workers. To prevent complete discrimination of the unemployed, and in line with empirical evidence, we assume that the arguments above apply only to a fraction r of the job openings in a given period.[18]

All these arguments can be criticized, however, by arguing that the firm could offer different wages for the different groups, each wage corresponding to the expected productivity (net of hiring cost) of a worker in that group. Thus there must be some rigidity of the wage structure that prevents firms from differentiating wages according perceived productivity differences. We will not try to explain this rigidity in the present paper, but we take it as a fact of life. It seems to be important for firms to have a "company wage policy" which the workers perceive as fair. Within-firm wage rigidity should be especially pronounced in unionized labor markets because unions tend to insist on "equal pay for equal work", and this prevents wage differentiation based on productivity differences which are not

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[17] This is not necessarily true in the model, so we have to check that it is true for the parameter values used in the simulations below.

[18] We may imagine that some firms always rank, but job applicants do not know this, or that some personnel managers rank. Formally, firms are indifferent between ranking and not ranking in the model.

readily observed by workers. Evidence that wages tend to be equalized for a given type of job can be found in Bishop (1987), Campbell and Kamlani (1997) and Bewley (1999).[19]

The level and persistence of Unemployment

With ranking, the search and wage setting decisions are made as before, but employed workers are more likely to get hired than unemployed workers are. We assume that workers do not know for which jobs ranking is applied but send in their applications at random. Using a_t to denote the probability that an *employed* searcher gets a job we now have:

$$a_t = r\frac{n_t-(1-s)(1-Sa_t)n_{t-1}}{(1-s)Sn_{t-1}} + (1-r)\frac{n_t-(1-s)(1-Sa_t)n_{t-1}}{1-(1-s)n_{t-1}+(1-s)Sn_{t-1}}.$$

(15)

With probability r the worker applies for a job where employed searchers are preferred and in this case the probability to get a job is hiring per firm divided by the number of employed searchers per firm. With probability (1-r) the worker applies for a job where the employer does not have any preference for a particular type of worker and in this case the probability to get a job is hiring divided by the total number of searchers per firm.[20] We see immediately that a_t is higher if more firms rank applicants. Solving (15) for a_t we get:

$$a_t = \frac{(n_t-(1-s)n_{t-1})(r-(r-S)(1-s)n_{t-1})}{(1-(1-s)n_{t-1})(1-s)S(1-r)n_{t-1}}. \tag{16}$$

Contrary to the case without ranking the fraction of employed workers looking for jobs, S, affects a_t directly. Proceeding exactly as before, we can use (3) and (16) to solve for $E_t[n_t]$ as a function of n_{t-1} (see Appendix 1). Now the employment rate to which the economy converges if there are no shocks is

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[19] What is important is not that all workers are paid the same wage, but that wages do not fully reflect productivity differentials.

[20] For this equation to make sense it must be the case that there are more employed job applicants than jobs i. e. $(1-s)Sn_{t-1} > n_t - (1-s)(1-Sa_t)n_{t-1}$. In case of a very large positive demand shock, employment in period t could potentially be so large that there are not enough employed job applicants. We disregard this possibility in our theoretical analysis, and check that the inequality is fulfilled for shocks of reasonable magnitude in our numerical simulations below.

$$n^{SS} = \frac{S(1-r) - s\Omega r}{(1-s)\left(s\Omega(S-r) + (1-r)S\right)}. \tag{17}$$

For the steady state level of employment to be positive the following condition must be fulfilled:

$$\frac{1-r}{r} > \frac{s\Omega}{S}. \tag{18}$$

Equation (18) gives a limit to how much ranking our model can take. If r gets very high we get a situation where equilibrium employment is equal to zero. That r cannot be too large is most evident if we consider the extreme case when employers hire almost only employed workers. Then employed job searchers have a very good chance to get a job even if there is massive unemployment, so firms will raise wages, and employment falls. In the following we assume that condition (18) is satisfied.

One may suspect employment to be lower the more ranking there is since ranking implies a less well functioning labor market. In Appendix 1 we show that this is in fact the case:

$$\frac{\partial(n^{SS})}{\partial r} < 0 \quad . \tag{19}$$

The intuition is the same as above: more ranking makes it easier for employed job searchers to get a job, so firms raise wages and the demand for labor falls.

Another interesting question is how ranking affects the persistence of unemployment. Solving (3) and (16) for expected employment, differentiating with respect to n_{t-1} and evaluating in steady state we get a measure of persistence (ρ) and differentiating once more with respect to r we can show that ranking increases persistence (see Appendix 1):

$$\frac{\partial r_m}{\partial r} > 0. \tag{20}$$

The intuition behind this result can be understood by extending the discussion in the non-ranking case. After a negative shock, the wage will not fall immediately to the new steady state level because, if it did, employment would recover very rapidly and there would be a very large number of vacancies and excessive turnover. Thus wages adjust slowly although the level of unemployment is high. Ranking reinforces this mechanism. When employed workers have priority for some jobs their chance to get a new job will depend less on the stock of unemployment and more on the number of vacancies. Put differently, a large stock of unemployment has a weak effect on wages when unemployed workers cannot compete well for the jobs, and this slows down wage and employment adjustment after aggregate demand has fallen.

Quantitative Effects of Ranking

Having showed analytically that ranking reduces the level of employment and raises persistence we now ask whether these effects can be quantitatively important. To answer this question we choose the following numbers for the fundamental parameters: s = 0.01, S =0.04, Ω = 4. These numbers are not meant to represent any specific economy, but they are in the range of parameter values "fitted" to the US and European labor markets in Section IV below. We then examine what happens to unemployment and persistence as we increase the fraction of jobs for which ranking occurs from zero to 40 percent. The period is taken to be one month.

The results are shown in Table 1. The last column shows the resulting *yearly* persistence of unemployment, defined as $r = r_m^{12}$. We see that without ranking there will be some, but not very much persistence. Ranking has large effects on both the *level* and the *persistence* of unemployment. If ranking is applied for 30 percent of the jobs, unemployment increases more than three times and becomes much more persistent.

Table 1. The Effect of Ranking on the Level and Persistence of Unemployment

	u	r
r=0.0	0.029	0.03
r=0.1	0.040	0.10
r=0.2	0.061	0.30
r=0.3	0.108	0.64
r=0.4	0.370	0.96

Comparing our results to those of Blanchard and Diamond (1994) who found substantial effects on wage dynamics, but only small effects on the steady state, one might wonder why we also get long run effects. Our interpretation is the following. In Blanchard and Diamond the wage is set according to the Nash bargaining solution and the state of the labor market affects wage setting via the ”threat point”, which they take to be the situation if the employed worker was to become unemployed.[21] This means that ranking has two competing effects on the wage. If an employed worker were to become unemployed, his chance to find a new job soon would be much better since he would be “first in line” for new jobs. But on the other hand he does run a small risk of becoming long-term unemployed himself, and then he is worse off by ranking. The simulations made by Blanchard and Diamond show that these two effects almost balance and the net effect on the wage is small - unless workers are very myopic.[22]

In our model the worker can continue to work at his old job if he does not get the one he applies for. Since employed job-searchers do not risk becoming long-term unemployed the second effect does not appear. Therefore, ranking has an unambiguous and strong effect on wages and employment also in the long run.

Effects of individual parameters

In Table 2 we report the effect on unemployment and persistence as we vary one parameter at the time, starting from a baseline case where 25 per cent of the firms rank applicants.

Table 2. Effects of a 20% increase in each parameter in an economy with ranking.

	s	S	Ω	r	u	ρ
Baseline case	**0.010**	**0.030**	**4.00**	**0.25**	**0.078**	**0.45**
s increases	**0.012**	0.030	4.00	0.25	0.110	0.56
S increases	0.010	**0.036**	4.00	0.25	0.069	0.36
Ω increases	0.010	0.030	**4.80**	0.25	0.112	0.62
r increases	0.010	0.030	4.00	**0.30**	0.109	0.64

In order to understand the effects of changes in the parameters, it is important to realize that firms are always on their labor demand curves, so if employment falls, it must be because wages increase, and conversely. Thus we can infer what happens to employment by examining *how wages are affected* by the parameter change for a given level of employment.

21 See Gottfries and Westermark (1998) for a criticism of this way of modeling wage bargaining.

22 Similar results have been obtained in other models; see Machin and Manning (1999).

Note also that persistence depends on *how quickly* wages adjust after a shock to employment.

A higher exogenous *flow into unemployment (s)* implies that for a given level of employment there will be more job openings, it will be easier for searchers to get a job. Firms therefore raise wages and unemployment increases. Also, there is an increase in persistence.

To understand the effect of an increase in *on-the-job search (S)*, consider equation (15). We see that an increase in job search has two counteracting effects on the probability for employed workers to get a job. More on-the-job search means that more workers leave their jobs and this increases the number of job openings, but there are also more applicants for jobs, particularly for the ranking jobs. Inspecting the right hand side of (15) we see that the latter effect dominates, so the more workers search on the job, the smaller is their chance to get a job. Therefore, firms reduce wages, employment increases, and there is less persistence.

It may appear counterintuitive that more on-the-job search implies less unemployment. Won't employed job searchers take jobs, which would otherwise be given to unemployed workers? In our model, this is not true because every job switcher leaves a new job opening, which is filled immediately.[23]

An increase in *wage pressure (W)* obviously raises wages and leads to higher unemployment, and it also slows down wage adjustment after a shock, so unemployment becomes more persistent.

As discussed above, *ranking (r)* has the same qualitative effect as wage pressure, but from Table 2 we see that *ranking has a relatively stronger effect on persistence*. Intuitively, an increase in r not only raises the probability that employed job-searchers find jobs, but also makes this probability depend more on the number of job openings and less on the unemployment rate (c. f. equation (15)).

III. Medium-term Wage Contracts

So far, we have assumed that wages are changed as often as search and hiring decisions are made, i. e. every week or month, but in practice wages are changed less frequently. Union contracts typically extend for 1-3 years, and less formal "implicit" contracts in non-union sectors probably also extend for some time. Since medium-term wage contracts themselves

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[23] If there was some delay in filling jobs, more job search would imply that more jobs are vacant, but this should be a minor effect.

contribute to persistence, it is important to compare these two sources of persistence and to examine the interaction between them.[24] We now assume that wages are fixed for N periods. To be concrete, we may take the period (t) be one month and assume that wages are changed in January each year, so N=12.

To avoid some technical complications in this case, we assume that the firm has to choose one employment level for the whole year after it has observed the shock for the current year.[25] Turnover occurs throughout the year. Now the efficiency wage condition corresponding to (3) becomes:

$$E_T\left(Nn_T^i\right) = -(1-s)cS'(w_T^i/w_T)E_T\left(a_{1T}n_{T-1}^i + (N-1)a_{2T}n_T^i\right), \qquad (21)$$

where T is a time index for years, E_T denotes the expectation conditional on information available when firms set wages for year T, a_{1T} is the probability to get a job in the first period of the wage contract (in January) and a_{2T} is the probability to get a job in the remaining periods (February-December). For simplicity we ignore discounting within the year. Considering a symmetric general equilibrium, defining Ω as before and using (16) we now get:

$$NE_T(n_T) = \Omega(1-s)E_T\left[\frac{n_T - (1-s)n_{T-1}(r-(1-s)(r-S)n_{T-1})}{(1-(1-s)n_{T-1})(1-s)S(1-r)} + (N-1)\frac{sn_T(r-(1-s)(r-S)n_T)}{(1-(1-s)n_T)(1-s)S(1-r)}\right]$$

$$\approx \Omega(1-s)\frac{E_T(n_T) - (1-s)n_{T-1}(r-(1-s)(r-S)n_{T-1})}{(1-(1-s)n_{T-1})(1-s)S(1-r)} + \Omega(1-s)(N-1)\left[H(E_T(n_T)) + \frac{H''(E_T(n_T))}{2}s^2\right] \qquad (22)$$

where

$$H(x) \equiv \frac{sx(r-(1-s)(r-S)x)}{(1-(1-s)x)(1-s)S(1-r)},$$

24 Also, the importance of unexpected shocks is much greater when wages are fixed for substantial periods.

25 If the wage is set for a year, but the firm is allowed to change employment every month, there will be complicated within-year employment dynamics. When hiring, firms take account of the probability that a hired worker quits in the next period, in which case they do not save hiring costs in that period. Such within-year dynamics appear peripheral relative to our purpose and we avoid it by assuming that employment changes once each year.

where we have used a Taylor approximation to the function H(x), H”(x) denotes the second order derivative, s^2 denotes the variance of employment and we have disregarded terms involving higher moments of the distribution.[26] As expected, persistence increases and this is illustrated in Table 3 where we set s, S and Ω as in Table 1 and show yearly persistence (ρ) for wage contracts of different length and different levels of ranking.

[26] In the simulations in Section IV the variance term is omitted since it does not affect the results in any significant way.

Table 3. Persistence (ρ) with one-month, one-year and two-year wage contracts.

	N=1	N=12	N=24
r=0.0	0.03	0.19	0.32
r=0.1	0.10	0.28	0.41
r=0.2	0.30	0.44	0.53
r=0.3	0.64	0.69	0.72
r=0.4	0.96	0.96	0.96

We see that wage contracts contribute to persistence but the effect is fairly modest compared to the effect of ranking. For example, increasing the length of the wage contracts from one to twelve months increases ρ to 0.19 while increasing the fraction of jobs with ranking to 30 % raises persistence to 0.64. Note also that with r equal to 0.3 or higher, the speed of adjustment of employment is so low in any case that medium term wage contracts add very little to persistence.[27]

IV. Interpreting the Difference between Europe and the US

Compared to the US, unemployment is higher in Europe, turnover is lower, and fluctuations in unemployment are much more persistent. An interesting question is whether the mechanisms discussed above could potentially explain this difference. To answer this question we now ask what the values of the fundamental parameters have to be if the outcome in the model is to be consistent with key labor market statistics for each of the labor markets in the US, Germany and France.[28] Our purpose is not to test the model, but simply to ask whether the mechanisms discussed here could *potentially* explain the dramatic differences that we see in labor market outcomes.

[27] We consider wage contracts that fix one wage for the whole contract period. In practice, union contracts that extend beyond one year typically specify one wage for each year and hence they are less rigid than the 24 months wage contract considered here. The one-year wage contract seems most relevant.

[28] We think of Germany and France as examples of European economies with high and persistent unemployment. We choose not to look at the Scandinavian countries since centralized wage setting differs in fundamental ways.

Before starting we should note that we did not allow for union bargaining in our model. Since unions tend to raise wages we can, informally, think of them as a factor that adds to wage pressure (Ω) in this model. Thus a high value of Ω may reflect a strong efficiency wage mechanism or strong unions or a combination of the two.[29]

We take the period to be one month and the length of wage contracts to be 12 months in all three countries. There are four fundamental parameters in the model: the fraction of the employed workers leaving to unemployment in each period, s, the fraction of employed workers that apply for a new job each period, S, wage pressure, Ω, and the fraction of jobs for which firms rank applicants, r. While s can be measured reasonably well we lack direct measures of the other parameters. However, we do have estimates of the following three empirical magnitudes: the job-to-job flow S times a, the fraction of the workforce that is unemployed u, and the persistence of unemployment ρ. These estimates, which have been collected from various sources, are reported in the first part of Table 4. The measurement of the different flows and stocks is discussed in Appendix 2. Obviously, the exact numbers can be questioned, but our simulations are only meant to illustrate the importance of various mechanisms. Also, we show below that our qualitative results are quite robust with respect to changes in input parameters.

We see that the flow between jobs is of the same order of magnitude as the flow into (and out of) unemployment in all three countries, but turnover rates are much lower in the European countries. All flows are between one quarter and half the rates observed for the US. Unemployment is higher in Europe and unemployment is much more persistent.

We now ask the following question: can we explain the observed differences between countries using this model? Put differently, are there plausible values of the fundamental parameters S, Ω, and r such that Sa, u and ρ take values consistent with empirical estimates?[30] Since we have three free parameters and three observable magnitudes, we have zero degrees of freedom, meaning that we can just identify the values of the fundamental parameters using the steady state equations in our model - provided that a solution exists. A

[29] Gottfries and Westermark (1998) develop a wage bargaining model where the union wage turns out to be equal to the "efficiency wage" times a "union markup factor". This has approximately the same effect as an increase in Ω in the present model. Unfortunately, the dynamic nature of the present model makes explicit treatment of bargaining technically complicated.

[30] In principle, one could examine how well the model explains other observations. With comparable time series data on labor market flows one could examine whether the model is consistent with cyclical fluctuations of these flows in different countries. Also, one could examine the relation between employment and wages, but this requires a more explicit modeling of the shocks (real and nominal). These topics are left for future research.

priori, it is not obvious that a solution exists, and even if a solution exists, the resulting parameter values may be implausible.

As it turns out, a solution exists and the implied values for S, Ω and r are presented in the second part of Table 4. At the bottom of the table we also report the implied chance for employed and unemployed job-searchers to get a job in steady state.

Table 4 Observable magnitudes and implied values for the parameters.

	Parameter	US 1968-86	Germany 1986-88	France 1986-88
Empirical estimates:				
Separations to unemployment	s	0.015	0.004	0.006
Job-to-job flow	Sa	0.012	0.004	0.006
Unemployment rate	u	0.07	0.08	0.106
Persistence	ρ	0.36	0.80	0.80
Fitted parameter values:				
On-the-job search	S	0.042	0.025	0.029
Wage pressure	Ω	3.540	6.174	4.855
Ranking	r	0.185	0.364	0.383
Implied chance to get a job:				
Probability employed	a	0.29	0.16	0.21
Probability unemployed	a^u	0.17	0.04	0.05

It seems that in order to "explain" the observed smaller worker flows, higher unemployment rates and much higher persistence in Europe with this model, we must assume that there is less on-the-job search, higher wage pressure, and more ranking in Europe than in the US.[31]

Interpretation of the Results

Why do we get this result? Consider the difference between the US and France! First, s is lower in France and since job-to-job flows are much smaller in France, it seems reasonable

[31] Note that our assumption that there are enough employed job searchers is fulfilled for all countries. For France, 1.2 percent of the jobs are filled every period and 2.9 percent of the employed workers search on the job. This leaves room for a 1.7 percent unexpected increase in employment within a month without running out of employed applicants to the ranking jobs.

that S is also lower in France. As we discussed in Section II, s and S have counteracting effects on unemployment and persistence so the net effect is ambiguous a priori. To see what a generally lower mobility implies in this model, consider what happens to employment and persistence as we change *both* s and S from the higher US values to the lower French values, keeping Ω and r at the US values. This is done in Table 5.

Table 5. Changes in unemployment and persistence as s and S change from the US values to the French values keeping W and r at US values.

s	S	u	*r*
0.01500	0.042	0.070	0.36
0.01275	0.03875	0.058	0.35
0.01050	0.03550	0.047	0.33
0.00825	0.03225	0.035	0.32
0.00600	0.02900	0.025	0.30

When we decrease the turnover rates, starting from values fitted to the US economy, we get *lower* unemployment and also somewhat lower persistence. The reduction in unemployment and persistence coming from lower s dominates the effect in the opposite direction from lower S. According to our model, the lower turnover rates characterizing European labor markets by themselves should imply *lower* unemployment and *less* persistence compared to the US. Thus, we have to find the explanation for the high and persistent unemployment in Europe among the other two factors.

Wage pressure and ranking have similar effects in the model: both tend to raise the level and the persistence of unemployment, but we saw in Section II that ranking has a relatively stronger effect on persistence.[32] This is why the simulation points to more prevalent ranking as a potential explanation of the much higher persistence observed in Europe.

Are the results robust?

As discussed in Appendix 2, there is some uncertainty concerning several of the numbers used to describe the different economies. How sensitive are our conclusions to the precise choice of numbers? To check this, we change the input parameters in our simulation one at the time,

[32] Put differently, if we increase wage pressure only until unemployment reaches the level observed for France, we get less persistence than what we observe empirically.

holding the other parameters constant. As can be seen from Table 6, our conclusion that ranking is more prevalent in Europe seems to be quite robust. We can increase or decrease every flow parameter by at least around 50 per cent without changing our qualitative conclusion.

Table 6. The intervals for which our result that European economies have a higher degree of ranking than the US holds when one input is changed at a time.

Input	France	Germany
s	$0.0025 \leq 0.006 \leq 0.0088$	$0.0019 \leq 0.004 \leq 0.0065$
Sa	$0.0023 \leq 0.006 \leq 0.058$	$0.0016 \leq 0.004 \leq 0.055$
r	$0.66 \leq 0.80 \leq 0.90$	$0.69 \leq 0.80 \leq 0.91$

Are the results plausible?

The wage pressure (Ω) and ranking (r) parameters do not have any obvious empirical counterparts. What is potentially observable is the magnitude of on-the-job search, and the chance to get a job for employed job searchers. By construction, a^u is consistent with the observed stocks and flows in the labor market, so we may alternatively consider the *relative* chance to get a job for employed and unemployed job searchers.[33] According to our simulations, employed job searchers in the US have almost twice as large a chance to get a job as unemployed workers, while employed job searchers in Germany and France have about four times greater chance to get a job.

Unfortunately, there are very few empirical studies of on-the-job search that we can use to examine whether the magnitudes in *Table 4* are reasonable. One of the few relevant studies is Blau and Robins (1990), who examined US data. They found that employed job searchers got about twice as many job offers as unemployed searchers, a number very close to what we get in our simulations. At the same time they got higher frequencies of job offers than is implied by our simulations, but this may be due to cyclical effects.[34] We have not found any comparable studies for Germany or France.

We may also ask whether institutional differences between the countries would lead us to expect more ranking in Europe. As discussed above, firms will rationally prefer to hire

[33] By construction $a^u = sn/\left(1-(1-s)n\right)$.

[34] Their study concerned job search in 1979 and the authors note that their data set has "considerably higher offer rate than other data."

already employed workers if they expect unemployed workers to have lower average productivity, and wages cannot be adjusted to make up for the difference in productivity. The loss of human capital (or negative signal) associated with unemployment should be similar in different economies, but there are strong reasons to believe that wages are more rigid in Europe. Unions typically tend to compress wage distributions, especially within groups with similar jobs and qualifications, and insist on wage differentials being based on objective and verifiable criteria – "equal pay for equal work". This role of unions is strongly emphasized by Freeman and Medoff (1984), for example.[35] Thus it seems likely that employers in Europe find it much more difficult to differentiate wages according to perceived productivity differentials compared to the US, where unions are nonexistent in most sectors. Consistent with this view, there is evidence that workers who are laid off in Europe get a smaller wage reduction compared to the previous job than US workers - *if* they get a new job.[36] Of course, their chance to get a new job is much smaller.

Wage pressure is found to be somewhat higher in Germany and France than in the US. As we noted above, unions can, informally, be thought of as a factor that adds to wage pressure (Ω) in this model. Thus a high value of Ω may reflect a strong unions. The finding that wage pressure is higher in Europe is quite sensitive to our choice of input parameters, however.[37]

These simulations should not be regarded as a test of the model, or as proof that ranking is important. The purpose of the simulations is only to illustrate the potential magnitudes of the effects. What we have shown is that ranking may be an important factor that affects the level and persistence of unemployment, particularly in Europe.

V. Discussion

The main purpose of the paper is to point to ranking as a potential reason for high and persistent unemployment. As the economy recovers from a recession, employment grows, and there are many job openings. This raises turnover and creates an upward pressure on

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[35] See also Freeman (1982) and, for more general evidence that unions tend to equalize wages, Blau and Kahn (1996, 1999). Westermark (1999) develops a union formation model where unions tend to compress wage differentials.

[36] Classical papers are Gibbons and Katz (1991) and Jacobson, Lalonde, and Sullivan (1993). Burda and Mertens (1999) review the evidence and report evidence for Germany. See also Grund (1999) and Bender et al. (1999).

[37] If we set $r = .9$ in Europe, we get even more ranking and somewhat lower wage pressure in Europe.

wages, which slows down employment growth. High unemployment puts downward pressure on wages, but if unemployed workers cannot compete well for the jobs, unemployment will have a weak effect on wages and the return to equilibrium will be slow.

It should be emphasized that this is not a purely mechanical effect that arises because employed job searchers take some of the available jobs.[38] Every job switcher leaves a job which is immediately filled, so the number of jobs available for unemployed workers is not *directly* affected by on-the-job search or ranking. In fact, it is readily verified that a^u is independent of r and S for given employment.[39] The persistence of unemployment is solely due to indirect effects of turnover on wages and labor demand.

Obviously, our model is very stylized. Many simplifying assumptions are made to make the model solvable and to highlight the main argument. We have abstracted from matching problems, search is modeled in a very simplistic way, quits into unemployment are taken as exogenous, and we disregard disincentive effects of unemployment benefits. We now discuss some of these simplifications and try to relate our analysis to the relevant literature.

In our model, there is excess supply in the labor market and employment is always determined by labor demand. *No matching frictions* prevent firms from immediately hiring the workers they want. Presumably, we could add some frictions without overturning the conclusions, but it is essential to our argument that firms typically face a *choice* between different applicants, some of whom are employed. We view this as a realistic feature of the model.

Search is modeled in a very simple way. There are no costs of search, so employed workers always search if they would like to change jobs. Unemployed workers always search and they are ready to take any job they can get. More realistically, there would be some search costs, so the search decision, particularly that of employed workers, would depend on the expected return to search, which depends on the state of the labor market. This point is emphasized by Burgess (1993) and Anderson and Burgess (2000) who document that labor

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[38] Burgess (1993) and Anderson and Burgess (2000) discuss congestion effects of on-the job search taking the number of job openings as exogenous. For other references, see Pissarides (2000). Note also that e. g. Pissarides (1994, 2000) uses the word persistence to mean that unemployment *responds slowly to shocks.* We refer to the fact that unemployment *returns slowly to equilibrium* after a temporary (cyclical) shock.

[39] In fact, a^u is always given by (7) – independent of r and S for given employment. This is readily verified by considering the stock/flow relations, or by noting that a^u is equal to the last term in (15), and using (16) to substitute for a_t.

turnover is so procyclical that the *share* of job openings going to unemployed workers is counter-cyclical.

Allowing for this in the model would make job search an increasing function of the chance to get a job: $S(w_t^i / w_t, a_t)$. We would expect the cross derivative to be negative: search is more sensitive to the wage if there is a higher probability to find a job. This modification will have an ambiguous effect on unemployment persistence. Consider an economy, which is recovering after a recession, so employment grows and there are many job openings. Higher a_t will make search more sensitive to wages, and this tends to raise wages. At the same time, more on-the-job search reduces the chance to get a job for employed job searchers (c. f. equation (15)) so firms can cut wages. Thus it is not clear whether labor demand will recover more or less quickly.

Quits into unemployment are taken as exogenous in the model. Implicitly, we assume that workers who want to look for another job need not quit their current job to do so, and that those who quit into unemployment do this for other reasons. This assumption is in line with evidence that unemployed workers spend a rather small fraction of their time on job search, so in most cases it is possible – often advantageous - to remain employed while searching for a new job.[40]

Since both search by unemployed workers and quits into unemployment are taken as exogenous, *unemployment benefits* do not matter. If some workers have to quit their job in order to look for a new job, or job search by unemployed workers is made endogenous, there will be a role for unemployment benefits, and quits will more procyclical. Also, the dynamic analysis will be complicated by the forward-looking aspects of quits and search.[41]

Our model emphasizes the demand side of the labor market. Supply side explanations of unemployment emphasize that generous unemployment benefits make unemployed workers, who have lost some of their human capital, search less intensely and unwilling to take the jobs they can get. Such mechanisms can explain high unemployment, but they seem less plausible as explanations of the *persistence* of unemployment. While it is true that unemployment persists if some of those laid off due to a negative shock are slow to return to employment, this type of effect becomes progressively less important as those who became unemployed at the time of the shock find jobs. So this type of model cannot explain a persistence of unemployment that is much larger than the average duration of unemployment for individual workers (see Pissarides (1992) and Bean (1994)). The dynamic simulation

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[40] For a review of such evidence, see Chapter 8 in Layard, Nickell and Jackman (1991).

[41] See Ljungqvist and Sargent (1995) for a model with endogenous quits.

model of Ljungqvist and Sargent (1998) illustrates this point. Assuming that workers lose on average 40 percent of their human capital when they become unemployed, and that the replacement ratio is as high as 70 percent, they get a very modest amount of persistence in their model.[42] Thus it seems hard to explain the extreme persistence of unemployment that we see in Europe using this type of model.[43]

In the model, we did not explain why some firms prefer to hire employed job applicants. Instead, our purpose was to examine *consequences* of such behavior for the level and the persistence of unemployment. The questionnaire studies quoted in the introduction suggest that ranking occurs, but to find out whether it is really important, we need more direct evidence on the hiring strategies of firms and the magnitude and effectiveness of on-the-job search. If our picture of the labor market has any relevance, ranking and on-the-job search are very under-researched areas of labor economics.

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[42] About 1/8 of the shock remains after two years; see Table 4 and Figure 8 in Ljungqvist and Sargent (1998).

[43] Available empirical evidence shows clear statistical effects of benefits on exit rates from unemployment, but most studies find a rather small effect. For reviews, see Layard, Nickell and Jackman (1991) and Holmlund (1998).

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Appendix 1: The Effect of Ranking on Employment and Persistence

To show that employment is lower with more ranking, differentiate (17) with respect to r:

$$\frac{\partial(n^{SS})}{\partial r} = \frac{\left[-S - s\Omega\right]\left[(1-s)(s\Omega(S-r)+(1-r)S)\right] - \left[-s(1-s)\Omega - (1-s)S\right]\left[(1-r)S - s\Omega r\right]}{\left[(1-s)(s\Omega(S-r)+(1-r)S)\right]^2}. \tag{A1}$$

To show that (A1) is negative we have to show that the numerator is negative. Factorization gives us:

$$\left[-S - s\Omega\right]\left[(1-s)s\Omega(S-r) + (1-s)(1-r)S - (1-s)(1-r)S + (1-s)s\Omega r\right]$$

$$= -\left[S + s\Omega\right]\left[(1-s)s\Omega S\right], \tag{A2}$$

which is clearly negative.

To find out how ranking affects the persistence of employment we need to derive the employment equation. Using (3) and (16) we get:

$$E[n_t] = \Omega \frac{(E_t(n_t) - (1-s)n_{t-1})(r - r(1-s)n_{t-1} + (1-s)Sn_{t-1})}{(1-(1-s)n_{t-1})S(1-r)}. \tag{A3}$$

Differentiation of (A3) with respect to n_{t-1} gives us:

$$r_m \equiv \left.\frac{\partial(E_t(n_t))}{\partial n_{t-1}}\right|_{n=n^{SS}} = \frac{(1-s)(r - r(1-s)n^{SS} + (1-s)Sn^{SS})(1-(1-s)n^{SS})}{(1-s)(r - r(1-s)n^{SS} + (1-s)Sn^{SS})}$$

$$\frac{-sn^{SS}(-r(1-s) + (1-s)S)(1-(1-s)n^{SS}) - sn^{SS}(1-s)(r-(1-s)rn^{SS} + (1-s)Sn^{SS})}{(1-(1-s)n^{SS})} \tag{A4}$$

where n^{SS} is given by equation (17). Equation (A4) can now be differentiated with respect to r. Let N and D denote the numerator and denominator in (A4) respectively. To show that the resulting expression is negative it is sufficient to show that D>N and that the derivative of the numerator is bigger than the derivative of the denominator.

By looking at the equation above we clearly see that D>N since the expressions in the numerator and denominator is similar except that the numerator contains two extra terms which can be written as:

$$-s(1-s)Sn^{ss}<0\,. \tag{A5}$$

Furthermore, it can easily be verified that the derivative of the numerator is bigger than the derivative of the denominator. The only thing that differs is the term

$$-s(1-s)S\frac{\partial n^{ss}}{\partial r}>0 \tag{A6}$$

in the derivative of the numerator and this expression is clearly positive so the derivative of the numerator is bigger than the derivative of the denominator. Combining these two facts concludes the proof.

Appendix 2: Data

The flow into unemployment (s).

We generally have fairly good estimates of this parameter. Before discussing the data sources, however, there are two things worth noting. First, since we are interested in steady state situations the flows in and out of employment/unemployment have to be equal. Second, in our model a worker is always either employed or unemployed and we do not formally model movements in and out of the labor force. These two factors add a bit of complication because empirical studies often present results where the flows are not perfectly equal and where out-of-the labor force is included with flows to and from it. In a complete model the flows in and out of the labor force should be included but for simplicity we choose to ignore such flows and take the steady state flows between employment and unemployment as the average of the in and out flows.

The exclusion of labor force dynamics can partially be justified by arguing that these flows merely represent the exchange of workers between in and out of the labor force; i.e. workers retiring and being replaced by workers directly out of school, parents taking child leave etc. Furthermore, as is shown in Blanchard and Diamond (1990) the most important dynamics in a recession is the increase in the net flow from employment to unemployment while the net flows to and from the labor force vary much less dramatically.[44]

For the US economy we use values from Blanchard and Diamond (1990). The data are Abowd-Zellner adjusted gross flow series, which are seasonally adjusted data from CPS studies. The data set covers the period January 1968 to May 1986 and gives us monthly figures. The flow to/from unemployment averages 1.4 million per month. To get this in fractional form we divide it with the average stock of employment taken from the CPS, which is 93.2 million. The result is a flow from employment to unemployment equal to 1.5 percent of employment.

For the continental European economies we use data from Layard, Nickell and Jackman (1991) based on OECD sources. These data measure the total inflow into unemployment so it includes flows from out-of-the labor force into unemployment but it also excludes workers who flow in and out of unemployment very quickly. For Germany they report an inflow rate into unemployment of 0.4 per cent monthly for the period 1986-88. For France the corresponding flow is 0.6 per cent.

The flow from job-to-job (Sa).

Data on this flow is generally of lower quality compared to data for the flows discussed above. Since there do not exist any direct studies of this flow we instead have to rely on approximations from other data. This is often done by using series of separations and new hires. The result is obviously less precision in the estimates than ideally but for our calibrations these data are sufficient.

For the US economy we continue to use Blanchard and Diamond (1990) as our data source. They conclude that job-to-job movements represent 60 per cent of quits in the manufacturing sector from 1968-88. Furthermore, they approximate quits to 0.401 million out of 19.739 million employed workers for the period 1968-81. This figure is confirmed by Akerlof, Rose and Yellen (1988) who report a monthly quit rate from 1948-81 of around 2 per cent. This implies a fraction of job-to-job movements of Sa=(0.401 / 19.739) 0.6 = 0.012.

For the continental European economies we have had some problems obtaining accurate data. We have found two principal data sources; Burda and Wyplosz (1994) report

[44] Alternatively, we may think of some of the people out of the labor force as “semi-unemployed”. In theory, we may define unemployment to include this stock, but it implies that our measure underestimates the true amount of unemployment.

data for 1987 from national statistics and Boeri (1999) who report data from the year 1992. Boeri gets his data by taking the annual hiring rate and subtracting all annual inflows into employment from unemployment and inactivity to obtain an employment to employment flow. For Germany, Burda and Wyplosz report a job-to-job flow of 0.0797 million per month implying a fraction of 0.0797 / 27.070 = 0.003. For France the corresponding figures are 0.0358 million and 0.0358 / 15.685= 0.002. These are extremely small numbers compared to the US. Boeri, on the other hand, reports corresponding flow rates of 0.0095 for Germany and 0.0073 for France. This means that around 60 per cent of all hiring in Germany as well as 50 per cent of hiring in France are job-to-job flows. Although the figures cover different time periods it is puzzling that they diverge so markedly.[45] In the simulation we assume that 50 per cent of hiring in both Germany and France is job-to-job flows and thus we assign the same numerical value to the job-to-job flow as to the flow from unemployment to employment, i.e. 0.004 for Germany and 0.006 for France.

Unemployment rate (u):

For the US we use the above mentioned average stocks from the CPS for the time period 1968-86 of 93.2 million employed and 6.5 million unemployed workers. This gives us an unemployment rate of 0.07.

For the European economies OECD (1999) reports an average unemployment rate between 1986-96 of 8 per cent for Germany and 10.6 per cent for France.

Persistence (r)

Different authors use very different techniques to estimate persistence and this means that it is difficult to compare different studies. Some studies estimate persistence in simple autoregressive models while some newer studies use the unobserved components (UC) technique. All studies conclude that persistence is higher in the European labor markets.

Two similar studies using standard econometrics are Blanchard and Summers (1986) and Alogokoufis and Manning (1988). The former estimate the persistence of unemployment with yearly data for a number of countries including a time trend and their estimates of ρ are 0.36 for the US, 0.94 for Germany and 1.04 for France. The second study, also with a time trend included, report estimates for the US 0.48, Germany 0.94 and France 1.04.

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[45] A potential explanation for the difference can be the fact that Boeri uses measures consisting of point-in-time observations that are 12 months apart and therefore does not take into account events occurring within the 12-month period between observations. This can lead to an overstatement of job-to-job flows.

In our calibration below we set r to 0.36 for the US and 0.80 for Germany and France. This means that we follow Blanchard-Summers but adjust the European values downwards. We do this partly because r may easily be overestimated if there are long-term structural changes affecting the natural rate of unemployment, and partly to avoid pushing the model to very extreme values.[46]

[46] If we set r very high, we get much ranking and little search on the job, and after a positive shock, there may not be enough employed job applicants for ranking firms to hire. Allowing for this would complicate the model.

Figure 1. The real wage and the aggregate employment level.

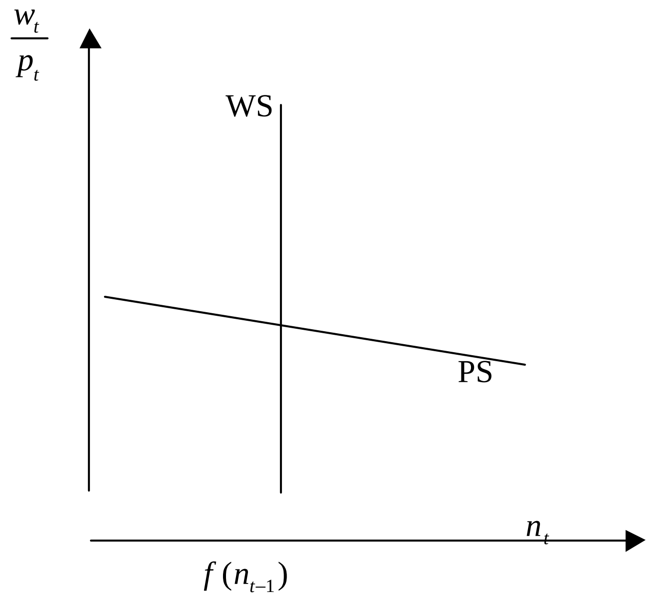

Figure 2. The nominal wage and the aggregate employment level.